The Strange World of Classical Physics

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We have heard many times that the commonsense world of classical physics was shattered by Einstein's revelation of the laws of relativity. This is certainly true; the shift from our everyday notions of time and space to those revealed by relativity is one of the greatest stretches the mind can make. What is seldom appreciated is that the laws of classical physics yield equally strange (or arguably even stranger) results if the observer happens to be in a very high velocity reference frame. This article addresses two questions: In Part I we examine what the world would look like if relativity was not in effect and you happened to be in a reference frame traveling at a high percentage of the speed of light or faster than light (perfectly allowable in this model), a conceptual world that existed on a foundation of Newtonian physics and the aether. It turns out that this is a weirder place than is generally realized. In Part II we see that classical physics in these frames is self-contradictory. Neither the consideration of Maxwell's equations nor the Michelson-Morley experiment is necessary to see these contradictions; they are implicit in the logic of the physics itself.

Part I

Living in a world going at high V which worked by the Newtonian rules would be "weird." To see just how weird, let's play baseball according to the model of classical physics in a world going almost the speed of light. This speed is measured relative to the aether (see below). We will call this situation "high V close to c."

Our native planet (Hermes) happens to be hurtling through space, such that at this part of its orbit around its sun, it is going through the aether at 99.99999985…%c. (i.e, 1 mph less than the speed of light).There is absolutely no physical reason in this model of the world why this would be impossible, so we will choose it for ease of visualization. We will call the direction of our planet's travel through the aether northward, for the sake of conversation (knowing full well that north has no real meaning in space, but we need to call our direction something). We will denote north as N and south as S. This would imply a high speed of the sun through the aether since the orbital speed itself would never be this high. This, in turn, could be due to that sun being in a galaxy hurtling through the aether with high V. In the most common classical model, the aether would blow right through the planet with no resistance. Now, in our laboratory, and outside on Hermes, we would measure the speed of light as about 1 mph in the northward direction but at almost $2c$ in the southward direction, with light propagating through space at intermediate speeds at intermediate angles.

We are attending a baseball game on Hermes. If the stands surrounded the baseball field in a circle with a 300-ft radius, then we would witness the following: When a player struck the ball, if you were situated in the N end of the stands, then you would first hear the bat strike the ball and then much later (about 3.4 minutes) see the bat hit the ball. This is how long it would take for light to reach you, propagating through the furious aether wind against it. The sound that is propagating through the medium of air, which is not moving relative to you, would travel at its normal speed of about 740 mph. Worse, during that 3.4-minute period, you would see a procession of previous batters hitting the ball, so that the sound you heard would be difficult to assign to any batter. Still worse, the ball could fly through the air invisible to you in real time and hit you on the head. Only after the impact would you see the image of the ball, and then, in a truly bizarre fashion: The first thing you would see would be the ball just before it hit your head and then a few feet before your head, and then gradually you would see the image unreel backwards, as a movie played in reverse, until a little over three minutes after the impact you would see it leave the bat to start coming towards you, information no longer useful.

This reverse unfolding is due to the fact that the baseball is traveling so much faster than light, the first light you would see from the baseball would be the light that reflected from it when it was a few inches from your head, because that light would get to your eye *before* the light that had left the baseball as it was hit by the bat, even though the light from that impact had been traveling for a longer time (but so slowly that the baseball leaves it far behind).

People in the south end of the stands would see the game pretty much normally because the image would reach them at nearly $2c$, while the sound would lag behind in the way we are used to.

This may sound ridiculous, but it is a direct consequence of following the assumptions that were deeply embedded in pre-Einsteinian physics. Before we go on, we should make those assumptions explicit.[1]

For physicists then:

1) All space was pervaded by a luminiferous aether—the medium through which light propagated. This aether was invisible itself, weightless, and matter passed through it without any drag. Light was a wave that propagated through the aether at a fixed speed (relative to the aether), which was known to be about 3 x 10^8 m/s (in a vacuum) and is denoted c. The aether could be considered to be the absolute framework against which all motion could be said to be measured.[2] So the phrase "a very high velocity frame" above means high velocity relative to the aether,

and the phrase "traveling at the speed of light" is also relative to the aether. In addition, Newton's three laws explained all mechanical phenomena, and the laws of electromagnetism explained the propagation of light and the other electromagnetic waves.

2) The measured velocity of light (denoted c) would depend entirely on the observer's velocity relative to the aether. If you (the observer) and your experimental apparatus were moving through the aether, in the direction of the light source, you would measure a higher velocity. If the observer was moving (with respect to the aether) in the direction away from the source, you would measure a lower velocity. These velocities would add or subtract in a straightforward linear way; if you were moving through the aether in the direction of the source at, say, half the speed of light (relative to the aether), you would measure a light velocity of $1.5c$, if in a direction away from the source, $0.5c$. It was exactly such a change in the speed of light due to the Earth's motion through the aether that the Michelson-Morley experiment was expected to detect.[3]

Now that we understand what light should behave like to a 19th-century physicist, let's go back to Hermes, where the strangeness is just beginning to unfold. If you were looking south through a telescope at something 25 miles away, you would see what had happened yesterday. If you were having a conversation and your interlocutor claimed you had said something five minutes ago, which you remembered otherwise, you could just walk N at 5 mph until you overtook the light from the conversation, turn around, focus your telescope on your own lips, record a videotape, bring the tape back to your friend and show it on a VCR (you should sit south of the screen), and prove by lip reading what you had said a few minutes before (very convenient).

Going south, light would propagate at a little under $2c$, a little too fast to walk past. In the event that the above proof caused a fistfight with your friend, then you would do well to position yourself S of him because you would see him normally, but he would see your fists coming toward him after the fact.

What would an object rotating around a vertical axis look like? Very strange indeed. Let's use a ruler for an example. Assuming it was rotating at any speed sufficient to have its extremities move faster than 1 mph, if you were standing N of it you would see the following: the edge coming towards you would be time delayed (as would all parts of the image), and you would see the approaching edge of several rotations ago. The actual light from the approaching edge now (in this pre-relativistic scheme, the word "now" has a quite real and unambiguous meaning) would be seen long after it had passed that position. The opposite edge, which would be retreating at the moment you were looking, would dim and change color. The parts of the ruler at different radii are all moving at different speeds, some above and some below the propagation speed of the light carrying the image. This makes the actual detailed math of what a simple spinning ruler would look like quite daunting ...and I leave it as an exercise for the reader.

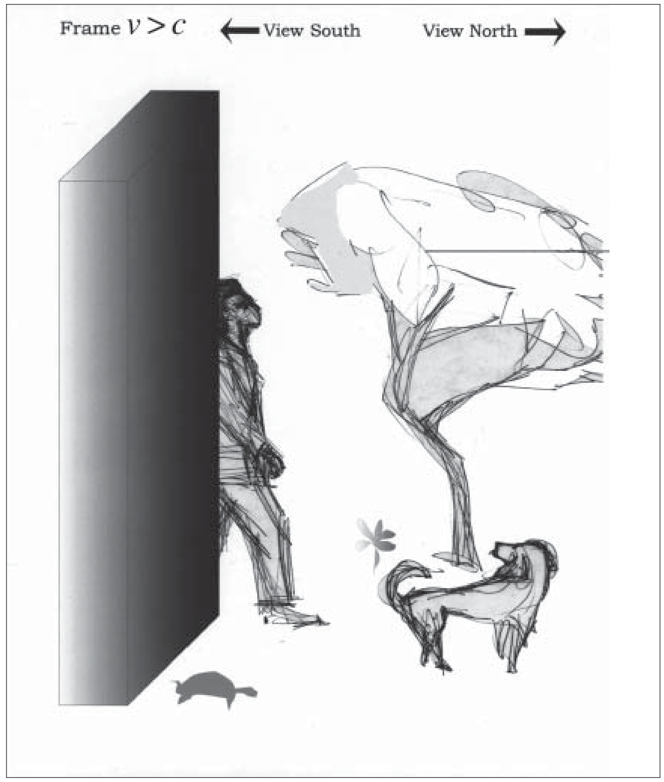

Fig. 1. The world as it would appear to an observer in a frame where $v > c$.

If, while walking north at 5 mph, you turned around and (still moving) looked backward, the world would disappear. The entire Southern Hemisphere would be a black hole to you optically. You would be able to hear, smell, taste, and feel the world normally, but the south-facing hemisphere would vanish from sight. No light that was leaving any object in that direction would be able to catch up with you. Only when you stopped and waited would the light from the south be able to impinge on your eye. As you were walking, you would have cleared a path through some of the "old light" that had been moving slowly in your path and you would have absorbed it on your body, leaving a sort of light-void path in the shape of your body, a kind of three-dimensional shadow. Therefore, when you stopped there would be a delay before the unabsorbed light from the south caught up and the world turned itself on again. Looking directly ahead as you walked, you would see events that happened directly behind you being played out in reverse.

Now let us consider another world whose velocity relative to the aether was $1.5c$. (Assume the same direction as the previous example.) In the classical view, there would be absolutely nothing to prevent this. So again, we will choose it for visualizing the logical consequences.

In such a frame (call it Planet Superluminous, see Fig. 1) even if you were sitting on the ground, when you faced south the world would be black, and if you faced north it would look normal. The only way to look at an object south of you would be to walk south past it and turn around to face north to see

it— the south side of it, that is. The north side of any fixed object (building, tree, etc.) would be permanently invisible; there would be no way (that I can think of) to get that light into your eye or a recording instrument. Your other senses would work as usual.

You would have some pretty interesting temperature problems, because along with light, radiant heat energy (infrared) would not reach you from the south, but you would be radiating with a vengeance in that direction, so the south side of your body would be quite cold, even if the air were at normal temperature. The north side, however, would be receiving radiation from the environment (north of it) normally and therefore be warmer than the south-facing side. You'd be normally warm on the N side and freezing on the S side, and had better turn yourself quite frequently, like a rotisserie chicken, to maintain some sort of equality. Even if the air and ground temperature were uniform in the environment (something, in fact, quite hard to maintain here), and there was no extraneous radiation impinging, you would have this permanent warm and cold side to every object.

In this frame you would have a permanent temperature disequilibrium maintained, even if you sealed the whole planet in a perfectly reflective enclosure, with no influx of radiation from the outside, no leakage of radiation, and no potential energy source being depleted on the inside. This is, to put it mildly, not in accordance with the laws of thermodynamics as understood at the end of the 19th century. This introduces us to more than mere strangeness; we now have our first intimations of theoretical inconsistency, which will be considered in Part II, with other examples.

I think the above justifies my claim that the classical world view is as strange or stranger than the Einsteinian-relativistic one; it's just that you have to pick the right frame to appreciate the strangeness. In the pre-Einsteinian world, each separate frame of reference presents a quite different physical reality (although the underlying laws of mechanics are the same). Children brought up in one wouldn't be able to function in others. In the Einsteinian framework, all reference frames are blissfully indistinguishable.

I would guess that the reason the implicit strangeness of the classical world was not more obvious and not more often dwelled upon is a historical accident. Before classical physicists happened to ask themselves the question of what life would be like in a high *V* frame, Einstein came along and offered a totally "other," and empirically provable, world view that made the question moot.

Part II

The necessity of reformulating classical physics

The entire foregoing discussion is based on a conceptual framework that works with the first two ideas (the existence of the aether as medium and the speed of the observer through the aether as determining the speed of light) that were understood in the 19th century. However, by the end of the 19th century and the beginning of the 20th, the structure of the atom was revealed (the essential features worked out by 1912), and it became known that the electrons carrying the negative charge were confined to the outside of the atoms, with the protons confined to the center. This, in turn, generated a new understanding of the way forces pass through solid objects (i.e., how a force applied to the one end of a rigid body results in the acceleration of matter at the other end). These last two aspects of physics were still within the framework of classical physics.

When this aspect of forces is considered, it turns out that the entire previous discussion is superficial and in need of radical restructuring, producing a set of predictions, if anything, stranger than the preceding ones.

It is germane to expand on how a force works its way through an object. For example, if you push on a stick with your hand, at the area of contact between your fingers and the stick, the atoms of your skin are impinging on the atoms of the stick. When an attempt to push atoms together is made, the electrons of one atom repel the electrons of the neighboring atom, which then push on the electrons in the next atom, etc., transmitting the force through the stick and causing all the atoms to start moving, so the force with which your hand pushes on the stick turns out to be transmitted by an electromagnetic field that surrounds each electron.

It was also understood, quite independently of relativity theory, that the electromagnetic field itself propagated through space at the speed of light (in this model, relative to the aether). This was given by Maxwell's equations, the second pillar of classical physics after Newton's laws. Even without Maxwell, empirical evidence from such everyday devices as the telegraph showed that the advancing wavefront of the electromagnetic field traveled at light speed. Therefore, in this model, when you push something, the "push" can only go as fast as light through the aether.

Now, when we include the above idea, the previous analysis changes radically. Let us go back to Hermes. Velocity through the aether is northward at such a velocity that the speed of light northward is 1 mph (relative to the planet frame). Let's (try) to push a stick northward. The atoms of your fingers move toward the atoms of the stick and the electromagnetic field starts to increase to transmit the force, but it can only travel through the stick at the speed of light, which is 1 mph in the northward direction. In effect, a wave of compression carrying the force passes through the stick. It is important to stress here that this limitation on propagation speed reflects a pre-Einsteinian understanding of force. The difference between this and the modern conception is that, in this model, the speed of light itself is frame dependent.

What happens here is that the classical logic tells us that in this situation it would be physically impossible to push a stick faster than 1 mph N no matter how hard you tried. Increasing the force a millionfold would not help, because the wave carrying the force could not possibly get to the front of the stick

faster than light speed. [This is a weird kind of pre-Einsteinian speed limit…in neither system (late classical or modern) could you push an object past the speed of light!]

In the example in Part I about walking faster than light to catch up to the visual record of your conversation, we have a problem: it is now evident that you couldn't walk faster than light because when the push to accelerate your body comes up your legs, it can't go faster than 1 mph N.

Nor could the baseball in the first example hit you before its image got to you, because no matter how hard it was hit, the baseball and its image could at most travel together. The sound of the baseball being hit would also be limited to this speed because sound is transmitted by one molecule pushing on another, which is also through the agency of the electromagnetic force. Therefore, with the transmission of forces reckoned, the baseball, its image, and the sound of its launch would all reach you at the same time, about 3.4 minutes after it was hit. In fact, the transmission of forces precludes any object on Hermes from ever going more than 1 mph N, if it was originally going slower.

I don't even want to think of what a rotating object would look like and, worse, be like on this version of Hermes. Let us say you put a motor on the axis of a horizontally placed rod and started it with a given angular acceleration. The advancing edge could not go faster than 1 mph N; as each outer radius section achieved 1mph, it would cease accelerating, but the adjacent inner radii section, which would have a slower speed, could still accelerate. But all parts of a straight spinning rod cannot be going 1mph, so does this mean the rod starts to bend and spiral around itself? Or perhaps the rod stays straight and the outmost point limit of 1 mph N puts a constraint on the inner sections of the rod, which go slower towards the center, in the ordinary configuration of a spinning rod.

What spoils the simplicity of the latter idea is that there is no reason why the force spinning the rod, and propagating from the center, can't be made great enough to bend or break the material the rod is made of. So when the outside edge reached 1mph N, would the rod on that end proceed to bend or break in an inward moving sequence? The retreating outer end (going S) can accelerate to any speed up to 2*c*, but then must slow down when it starts going N. Or does it have to? If it is already traveling faster than the speed of light when it swings around, and enters the N direction, does this mean it has effectively become the analog of a tachyon[5] in this system, permitted to exist because it entered the northward direction going faster than light, and requires no further force transmission from other parts of the rod to maintain that speed? Is the spinning rod composed of sections going N at 1 mph top speed and sections retreating S at an ever increasing rate and then becoming sections going north as effective tachyons? Just what is the shape of this rod at any moment?

I don't know, and I think this would take some rather intensive work by mathematical heavyweights to get ironed out. I leave this as well as an exercise for the reader. This is a very lopsided world indeed, and, more important for physicists, here we have grounds for more than the mere strangeness we had in Part I; here we have grounds for an actual contradiction within classical physics.

Assuming only the properties given above (each well within the legitimate assumptions of classical physics), we find that on Hermes in some cases $F \neq ma$. Newton's second law is not in effect because if you push on an object and continue to push indefinitely, it will not continue to accelerate; it will reach a top speed of 1 mph N. The third law in this aether-bound system was also compromised as soon as the transmission of forces at finite velocity was incorporated. If you have two electrically charged particles A and B, where B is positioned 100 m south of A, and you then move A closer, then at the moment (again, a unique and universal instant in the classical model) the higher electrical force from A impinges on B, B is *not* exerting an equal and opposite force back on A. This difficulty was already known at the end of the 19th century, but, in our high V frame, what was an inconsistency of small duration becomes highly exaggerated and, worse, asymmetrical, because the increased force propagating southward would take less than a millionth of a second, but at 1 mph in the N direction it would take three+ minutes to reach back to A.

One cannot exaggerate the depth of this contradiction. Newton's second and third laws are not something the body of classical physics can readily dispense with—they are the logical foundation of it. We have reached an impasse. This means that if you were living in the early years of the 20th century, you would not need the Michelson-Morley experiment or Einstein's relativity to realize something was amiss with physics; all you would need were the standard assumptions of your time, and the thinking through of what your physics would predict at high V reference frames, in order to see that your conceptual framework was incomplete or even inconsistent. The examination of the world of high V frames would not in itself point to the specific solution of special relativity, but it is surprising to see that such contemplation would have revealed a striking rift within the body of classical physics, and showed that some such radical revision was a necessity.

Postscript

It is important to realize that the entire analysis given in Parts I and II is itself only a beginning, intended to "open the door" on this topic. I think that many of the results arrived at above will show themselves to be in need of addition, modification, or correction. When a complete thinking through of the implications of high V reference frames in classical systems is carried out, additional unnoticed influences and effects will come to light. I look forward to this process, and predict with confidence that what a further analysis of these frames will reveal is many more inherent inconsistencies. This has strong implications for the history of ideas. It is intriguing to see that hidden in classical physics, which seemingly was circumscribed by a commonsense-based and intuitive framework, was an implicit world of deep strangeness and

even contradiction. There are even implications for the ongoing process of constructing consistent physical theories today, especially in theoretical developments that treat space as a fluid.[4]

"Cut nature at the edges," Plato enjoined us. This particular edge yields a truly intriguing vision of a classical world that we mistakenly took as always behaving in a sensible and ordinary way.

References

1. This is not to say that the viewpoint of classical physics was monolithic. By the end of the 19th century, even before Einstein, many of these assumptions were being reexamined by Lorentz, Poincaré, FitzGerald, and others. The thought that something needed to be changed within the classical framework goes back all the way to Newton himself, who refused to believe that objects could exert an instantaneous force at a distance on each other, and therefore thought that his own third law would need revision. The assumptions given here could be called the mainstream, or the working set of assumptions that most physicists used everyday.
2. Holton, Rutherford, and Watson, *Project Physics* (Holt, Rinehart, and Winston, 1975), Unit 4, pp. 117–119.
3. T. M. Heliwell, *Special Relativity* (Allyn and Bacon), p. 12.
4. Theodore A. Jacobson and Renaud Parentani, "Echoes of black holes," *Sci. Am.* **293** (6), 68-75 (Dec. 2005).
5. In special relativity it is not actually specified that an object can never move faster than light…a particle moving originally slower than light through space can never be accelerated up to, or beyond, light speed, but many physicists interpret the equations to say that a particle that was always going faster than light might be permitted to exist. Such a hypothetical particle is dubbed a *tachyon* and has many delightful and bizarre properties.

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